ARMORED MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

Final Report On

PROJECT NO. 44 - PHYSIOLOGICAL AND OPERATIONAL CHARACTERISTICS OF M-24 TANK

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Project No. 44

8 November 1944

ARMORED MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky

Project No. 44
470.8-2 SPMEA

8 November 1944

Final Report On

1. PROJECT: No. 44 - Physiological and Operational Characteristics of M-24 Tank.

a. Authority: Letter, Commanding General, Headquarters Army Ground forces, Army War College, file 470.8 GNROT-691272, dated 17 July 1944.

b. Purpose: To appraise subject tank from the standpoint of physiological characteristics and limitations.

2. DISCUSSION:

a. The detailed results of observations and tests are presented in the Appendix.

3. CONCLUSIONS:

a. Provision for drawing heated air from engine compartment for crew compartment ventilation in winter is potentially dangerous.

b. Present system of ventilation is inadequate for control of gun fumes.

c. Provisions for close-in general vision are inadequate.

d. Driver's vision should be improved.

e. Fire control provisions are satisfactory except for fact that present arrangement will not accommodate M10 periscopic sight. Head rest adjustment on telescope should be improved.

f. Bow hatch locks for open position not sufficiently positive for operation over rough terrain.

g. Effort required to open escape hatch is too great.

h. Padding around hatch openings is insecurely fastened.

i. Seat backs are not easily removed and more positive fasteners are required for seat cushions.

j. There is insufficient space for accelerator pedal action when large shoes and arctics are worn.

k. 75 mm gun recoil interferes with commander's right leg.

4. RECOMMENDATIONS:

a. Eliminate provisions for winter heating of crew compartment which draws air from engine compartment.

b. Provide an independent system of positive-pressure ventilation for crew compartment of not less than 800 cfm.

c. Immediate consideration be given to the development of an improved vision cupola with less limited ground vision and installation of vision units to provide close ground vision on the loader's side.

d. Immediate consideration be given to improvement of driver's vision.

e. Make provisions for accommodation of M10 periscope sight.

f. Improve telescope head rest adjustment.

g. Provide positive locking device for bow hatches when open.

h. Improve unlocking device on escape hatch to reduce effort required in operating.

i. Provide positive fasteners on seat cushions.

j. Improve seat back of mounting for easier removal.

k. Provide more clearance for operations of accelerator pedal.

l. If possible, dish-in 75 mm gun recoil guard to provide leg room for commander.

m. Re-locate forward turret light fixture to central position shown in Figure 3.

(NOTE)

The following are the comments and recommendations as set forth by Headquarters Armored Center, Kent C. Lambert, Colonel, Acting Chief of Staff:

1. The following comments are submitted on the recommendations of the Armored Medical Research Laboratory Project No. 44, "Physiological and Operational Characteristics of M-24 Tank":

a. Paragraph 4a.

The elimination of the carbon monoxide hazard resulting from the present method of winter heating for the crew compartment is considered essential;

however, the correction of this defect should be accomplished in such a manner as not to affect the production rate of Light Tank, M-24. All units now equipped with Light Tank M-24 should be cautioned regarding the carbon monoxide hazard. Action should be taken to insure that the hot air controls remain closed except for necessary maintenance operations.

b. Paragraph 4b.

(1) The present M-24 Tank has been found to be a fightable vehicle as it now exists, the gun fume hazard having been taken care of by providing for operation of the engine at 1500 RPM while the bulkhead doors are open during firing of the 75mm gun, as described and approved in paragraph 1g, Armored Board Project 482, "Test of Light Tank T24 (Firing Phase)" and paragraph 5, 2nd indorsement, letter Army Ground Forces, file 470.8 (2 Aug 44) GNRQT-6/91610.

(2) A blower of not less than 800 CFM capacity should be incorporated in the future production of Light Tank, M-24, in such a manner as not to reduce the production rate. This modification is classified desirable.

c. Paragraph 4c.

The provision of an improved vision cupola in future production is considered desirable. No vision device which will result in decreasing the armor protection now afforded is considered acceptable.

d. Paragraph 4d.

Improvement of driver's vision is desirable, but must be accomplished without decreasing the armor protection now afforded.

e. Paragraph 4e. Accommodation of the M10 periscope sight has been provided for in paragraph 3, 2nd indorsement, letter Army Ground Forces, file 470.8 (2 August 1944) GNRQT-6/91610. Recent observation of vehicles coming off production line indicate this has not been done. The incorporation of Periscope M10 is considered an essential modification of the utmost urgency. Provision for incorporation of Periscope M10 should be made without affecting the production rate of Light Tank, M-24.

f. Paragraph 4f. - Desirable for future development.

g. Paragraph 4g. - Positive locking device for bow hatches when open is now provided in production model of M-24 Tank.

h. Paragraph 4h. - The present unlocking device has been found in some instances to require excessive effort to manipulate. It is requested that it be investigated and steps be taken to provide a more efficient lock. This is classified as desirable.

i. Paragraph 4i. - Desirable for future development.

j. Paragraph 4j. - Now included in production tanks.

k. Paragraph 4k. - Not concurred in by this headquarters.

l. Paragraph 4l. Not concurred in by this headquarters.

m. Paragraph 4m. Desirable for future development.

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3 Incls:
#1 - Appendix
#2 - Table 1
#3 - Figs. 1 thru 3

APPENDIX

I. VENTILATION

1. Ventilation of the M24 Tank is of the negative-pressure type. The system is more complex than in the M4 series tanks in that the rate of ventilation can be varied by adjustment of bulkhead panels. It differs further in that heated air from the engine compartment can be delivered into the crew compartment for winter operations. No hull ventilators are provided; this fact together with the tightness of the bow and ease of leakage in the turret produces poor distribution of air flow through the crew compartment. An auxiliary fan of limited capacity and reversible in operation is located in the bow.

2. Control of Gun Fumes. Standard gun fume tests were conducted with the ventilation system varied in operation as regularly provided for in the tank. In addition, tests were made with an auxiliary fan of 1000 cfm installed in the bow. Details of tests, results and conclusions follow:

a. Fire Pattern:

(1) 75 mm gun: The piece was fired at the rate of one (1) round every 10 seconds in bursts of 5. Two bursts were fired at 5 minute intervals in each test.

(2) Machine Guns: The machine guns were fired at the rate of two (2) rounds every 2 seconds. Two belts of 250 rounds were fired in each test, about 1 minute being allowed for reloading.

(3) Ammunition: 75 mm, Super HE M48. Machine Gun, caliber .30 ball.

(4) Tank Operation: The test conditions were varied as follows:

(a) Engine speed: dead, 500 rpm, 900 rpm, and 1500 rpm.

(b) Hatches: Completely closed, and commander's hatch open.

(c) Bulkhead and floor ports: Summer arrangement with the bulkhead doors open (to last stop on retaining bar) and the floor ports closed. Winter arrangement, bulkhead doors closed, floor ports open. Heated air from the engine compartment was forced into the crew compartment in the latter arrangement. The sliding panels on the bulkhead doors were closed in all tests.

(d) Auxiliary ventilation: Three different bow fans were used in the tests. (1) original fan, at high speed, intake and exhaust. (2) original fan with the housing replaced by a

fan housing from the auxiliary fan of an M5 tank. (This housing has two adjustable elbows which permit directing the discharge of the fan). Tested at full intake and full exhaust and with the discharge split between driver and bow gunner and with both discharge openings directed to the bow gunner's side. (3) Fan supplied by OOO-D capable of delivering in excess of 1000 cfm. This fan was mounted at the center of the upper edge of the bow access plate. Tests were run with air flows of 400, 800, and 1000 cfm. This fan was of the axial flow type and draws 29 amperes at 22 volts.

(e) With a number of the above combinations, tests were run both with a machine gun fitted with a #718 muzzle plug and with an M1 muzzle plug. The latter produced 3 to 5 times higher air concentrations of carbon monoxide than the former.

(5) Analysis: Air samples were analyzed for carbon monoxide by the MSA indicator, the infrared selective gas recorder, and by chemical analysis of collected air in glass flasks. Sampling ordinarily consisted of collecting at the loader's breathing zone when firing the turret pieces and at the bow gunner's breathing zone when firing the bow machine gun. In some of the tests sampling was carried out simultaneously at other crew positions.

b. Results of Tests:

The results of the tests are assembled in Table 1. It will be noted that with the ventilation set for summer operation, it is necessary to increase the engine speed to 900 rpm to attain even fair control of fumes, but even then the bow condition was not satisfactory. In an effort to correct this difficulty, the bow fan housing was changed to the type used in the M5 tank which provided for directed discharge through two adjustable pipes instead of a diffuse discharge. By directing the auxiliary air toward the machine gun it was thought that the local concentration of gas would be diluted and dispersed. Such was the case, but the changed pattern of air movement had a secondary effect, namely a deterioration of turret ventilation which resulted in excessive CO concentration from the 75 mm guns. This demonstrated clearly the precariously low ventilation of the tank, and led to the conclusion that the only practicable solution of the problem lay in the direction of providing completely adequate ventilation that would be independent of engine speed and that would not require adjustment of a complex group of doors, hatches and fan speeds.

To this end an axial flow fan supplied by Ordnance was mounted at the center of the upper edge of the access plate on the bow slope, a plywood panel being substituted in the test for the armor plate. This point of installation was chosen as approaching most nearly the location of the bow mushroom ventilator, the logical point of installation. This fan was of the axial flow type, had a capacity in excess of 1000 cfm, drawing 29 amperes at 22 volts. A variable orifice

was mounted over the intake so that the air flow could be controlled. Tests were run at 3 openings of the orifice, thus providing ventilation at 400, 800, and 1000 cfm, respectively. Owing to the considerable air leakage of the tank, especially around gun and turret ring, no significant positive pressure was developed; even with 1000 cfm it was only 0.04 inch.

The tests clearly demonstrate that 400 cfm is inadequate, and that a minimum of 800 cfm is required. As can be seen from Table 1, carbon monoxide was well within the tolerable limit while firing the turret pieces with the engine dead, at 500 rpm, or with the commander's hatch open when 800 cfm was used. The same was true for the bow gun when a #718 muzzle plug was used on that piece; however when an M1 plug was used on the bow gun a concentration of .052% carbon monoxide was found at the bow gunner's position at 800 cfm. Though this exceeds the acceptable level (0.05%) for ½ hour's exposure, it represents the lowest concentration found with this muzzle plug in all the test arrangements studied (excepting 1000 cfm).

3. Winter Ventilation. The gun fume problem (see Table 1) does not appear to be a primary consideration. However, in buttoned-up operation with the winter system delivering air into the crew compartment, carbon monoxide was consistently found in the turret air in concentrations of 0.03 - 0.04% and in one instance as high as 0.06%. These findings in a tank that has seen only slight service demonstrate the serious potential hazard of using engine compartment air to heat the crew compartment since leakage is bound to increase with use and wear. The present system for winter heating, therefore, cannot be accepted.

II. GENERAL VISION

The overall limits of close-in ground vision from all the various crew positions are shown in Figure 1 and for the driver in more detail in Figure 2. The absence of close-in vision on the right flank and poor vision on the left are serious faults, especially in view of the probable use of this tank in Pacific theatres where protection against ground troops is particularly required. In order to increase the close-in vision, an improved vision cupola for the commander is needed and rhombic vision units to provide vision within 5 feet of the tank should be installed in the right turret wall for use by the loader.

Driver's vision is limited by the restricted field of view of the present periscope. Wide-field vision units should be provided; for suggested approach to design see AMRL report on Analysis of Physiological Characteristics of T9E1 Tank, dated 27 March 1944 and report on Driver's Vision in Landing Vehicle Tractor, dated 9 March 1944.

The left side of the wind shield holder bracket obstructs the driver's vision in open driving. The bracket should be inclined downward, following the forward sloping contour of the tank.

III. FIRE CONTROL

No provision is made for M10 periscopic sight; otherwise conditions are satisfactory. The positioning of the gunner is good. More convenient adjustment of telescope head rest is needed. A simple weather guard for the telescopic sight and operable by the gunner is desired.

IV. HATCHWAYS

1. A more positive lock is required for the hatch in the open position to prevent release of the hatch when driving over rough terrain. Instances of this type of failure have been reported by the Armored Board and there is possibility of severe injury resulting therefrom.

2. The padding surrounding the bow hatch openings is not well secured and had already become loosened in the relatively new tank inspected.

3. Entirely too much effort is required to open the escape hatch. The required pull should not exceed 40 pounds, as previously recommended (see Letter Report to CG, AGF, Requirements Section, dated 15 September 1944).

V. SEATS

Height adjustments satisfactory. The seat backs were difficult to remove. Since this feature is provided primarily as a safety measure to permit rapid movement within the tank in an emergency, it is evident that ease of operation is essential. More adequate fasteners should be provided for seat cushions. If more certain snap fasteners cannot be obtained then belt buckle type fasteners should be applied on the under side of the cushion. Although this is less convenient than use of snap fastener, it would be better than having the cushions become loose and mat up, as is now the case.

VI. CONTROLS

1. The accelerator pedal should have a guard on the right side and/or the linkage guide arm moved interference in depressing pedal. With the present arrangement, men with large shoes and wearing arctics can operate the accelerator only by applying pressure almost entirely on the right side of the foot.

2. The 75 mm gun recoil guard should be dished in, if possible, to allow for more room for commander's right leg.

3. The present fibre lock nut on the manual traverse worked loose, causing increase in brake adjustment. A positive locking cotter key is required.

VII. LIGHTING

The present positioning of light fixtures in the turret does not allow sufficient light for the commander for map reading. The left forward turret fixture should be moved from existing position to central location shown in Figure 3. This position also provides more general illumination on main gun breech and radio.

TABLE 1

AVERAGE CARBON MONOXIDE CONCENTRATIONS WHILE FIRING THE WEAPONS IN THE M24

Air was sampled at the loader's position when firing the 75 mm and turret machine gun, and at the bow gunner's positions while firing the bow gun. Data by the infrared selective gas analyzer.

HATCHES	FAN operated at full speed except where noted		SUMMER Bulkhead Doors Open Floor Ports Closed									WINTER Bulkhead Doors Closed Floor Ports Open								
			500 rpm			900 rpm			1500 rpm			500 rpm			900 rpm			1500 rpm		
			75	TMG	BMG	75	TMG	BMG	75	TMG	BMG	75	TMG	BMG	75	TMG	BMG	75	TMG	BMG
Closed	ORIGINAL FAN	In	.154	.049@	.118	.013	.028@	.082	.018	.070	.108	-	-	-	.030*	-	-	-	-	-
Closed	ORIGINAL FAN	Out	.218	-	.166	.017	-	-	-	.054	.112	-	.034	-	.047**	.028@	-	-	.012	.231
Comm. Open	ORIGINAL FAN	In	.142	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Closed	M5 FAN IN	Split	-	-	.084	.097	-	.053	.009	-	-	-	-	-	-	-	-	-	-	-
Closed	M5 FAN IN	Bog Only	-	-	.060	-	-	-	-	-	-	-	-	-	-	-	.026	-	-	-
Closed	M5 FAN OUT	Split	-	-	-	-	-	-	-	-	-	-	-	-	.052	-	-	.027	-	-
Closed	M5 FAN OUT	Bog Only	-	-	.053	-	-	-	-	-	-	-	-	.090	-	-	.068	-	-	-
Closed	AXIAL FLOW FAN	400 cfm	.062	.048	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Closed	AXIAL FLOW FAN	300 cfm	.010	.009	(.052 (.013@	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Closed	AXIAL FLOW FAN	1000 cfm	.004	.004	.028	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Comm. Open	AXIAL FLOW FAN	800 cfm	.002	.031	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		ENGINE DEAD																		
Closed	AXIAL FLOW FAN	800 cfm	.005	.008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Recirculation (bulkhead doors open) gave .056% for 75 mm

** Recirculation (bulkhead doors open) gave .025% for 75 mm

@ #718 Muzzle Plug, all other machine gun data was obtained with machine guns fitted with an M1 muzzle plug

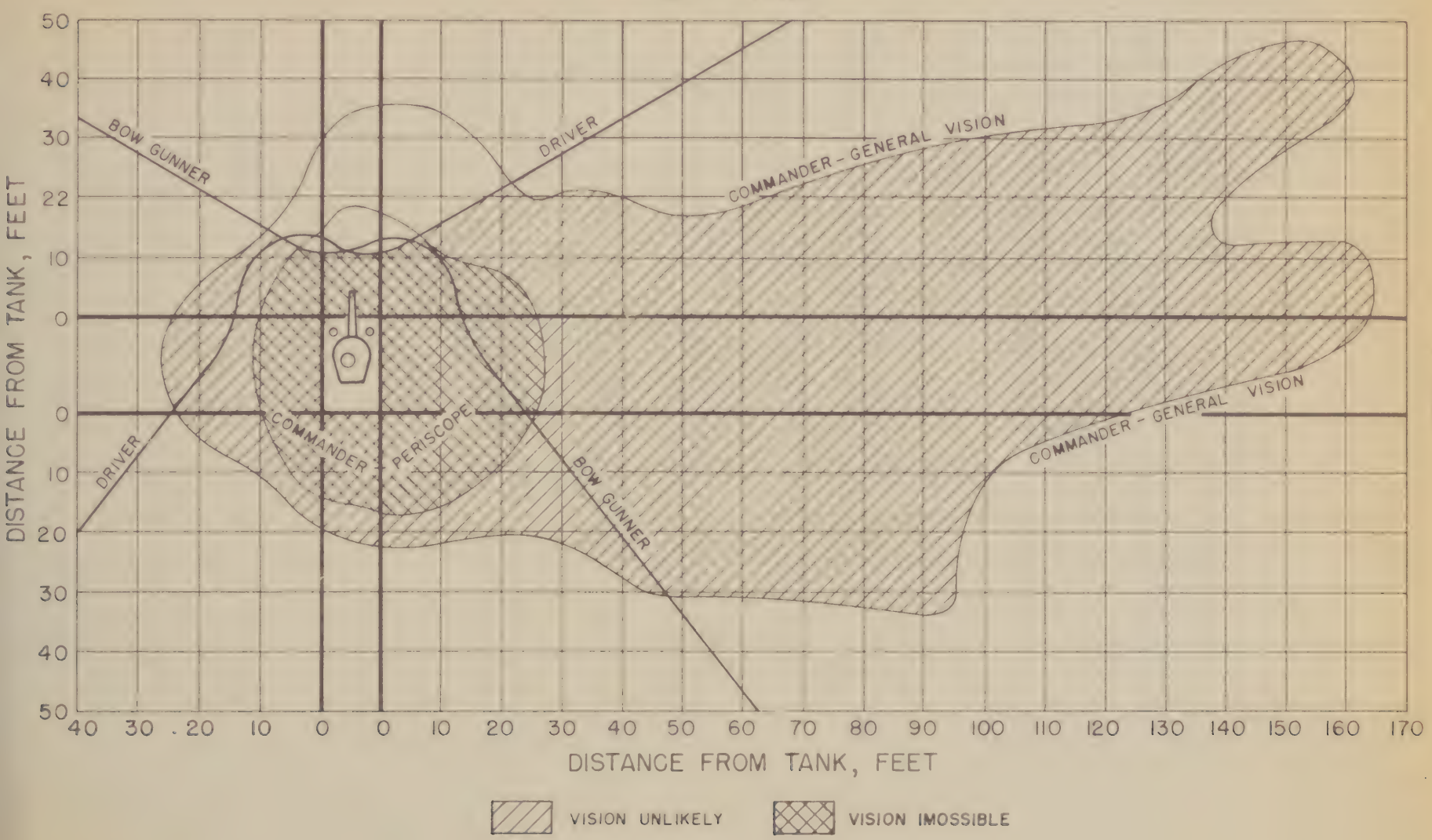

OVERALL LIMITS OF GROUND VISION
(ALL CREW MEMBERS)
M 24 TANK
DISTANCE FROM TANK, FEET
50
40
30
22
10
0
0
10
20
30
40
50
40 30 20 10 0 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
DISTANCE FROM TANK, FEET
BOW GUNNER
DRIVER
COMMANDER - GENERAL VISION
DRIVER
COMMANDER
PERISCOPE
BOW GUNNER
COMMANDER - GENERAL VISION
VISION UNLIKELY
VISION IMOSSIBLE

FIG. 1

FIG. 1

FIG. 2

LIMITS OF DRIVER'S GROUND VISION

M 24 TANK

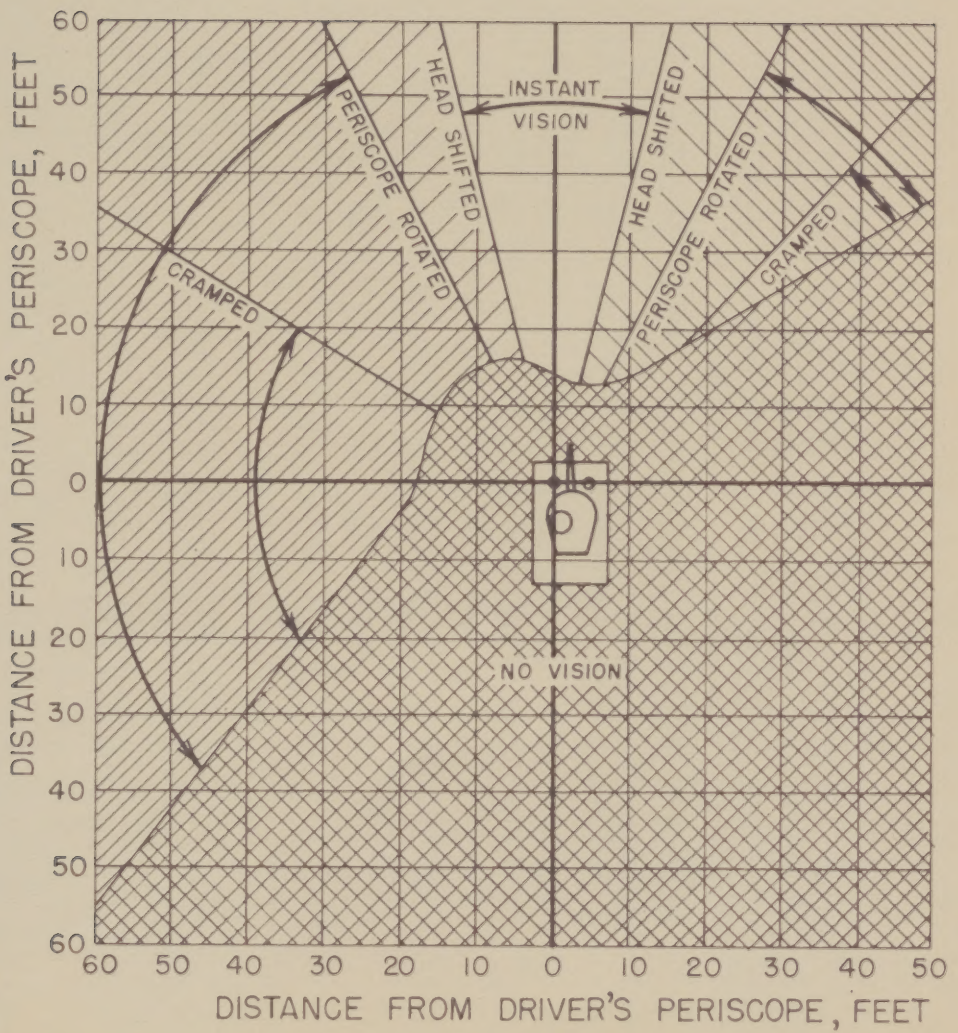
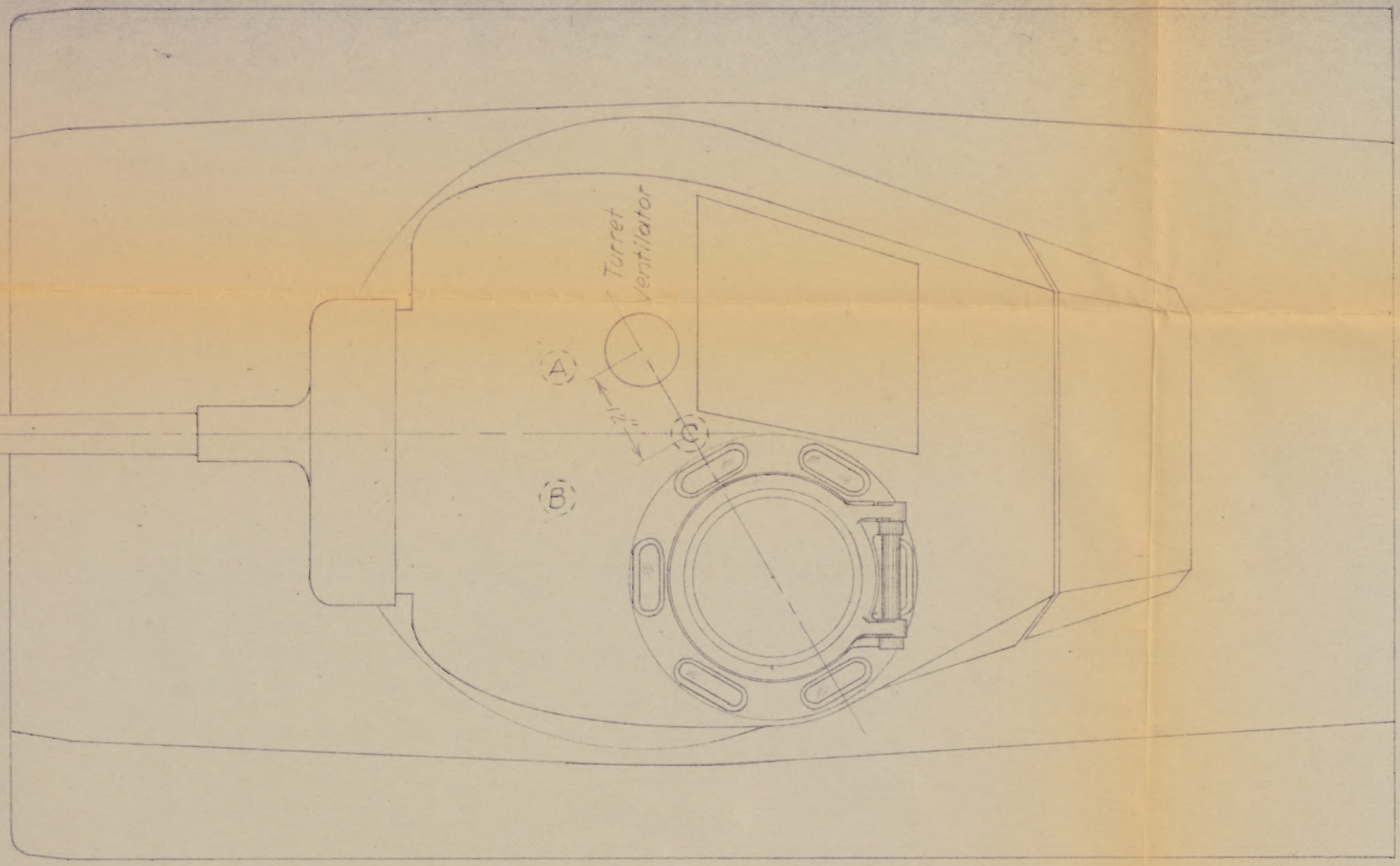


FIG. 2



Fixture A to remain in existing position
Fixture B to be moved to position C

FIG. 3

RECOMMENDED POSITIONING OF TURRET LIGHT FIXTURES IN M-24 TANK

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Engineering Section

SCALE NOT TO SCALE | DATE